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Tenkiller Ferry Reservoir Cherokee and Sequoyah Counties, Oklahoma

National Eutrophication Survey, Las Vegas, Nev

Prepared for

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REPORT

ON

TENKILLER FERRY RESERVOIR

CHEROKEE AND SEQUOYAH COUNTIES

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 933

WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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CHEROKEE AND SEQUOYAH COUNTIES, OKLAHOMA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

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Corvallis Environmental Research Laboratory
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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Oklahoma Department of Pollution Control for professional involvement, to the Oklahoma National Guard for conducting the tributary sampling phase of the Survey, and to those Oklahoma wastewater treatment plant operators who provided effluent samples and flow data.

Dr. Denver Talley, Director, Oklahoma Department of Pollution Control; the staff of the Oklahoma Water Resources Board; and the staff of the Oklahoma State Department of Health reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

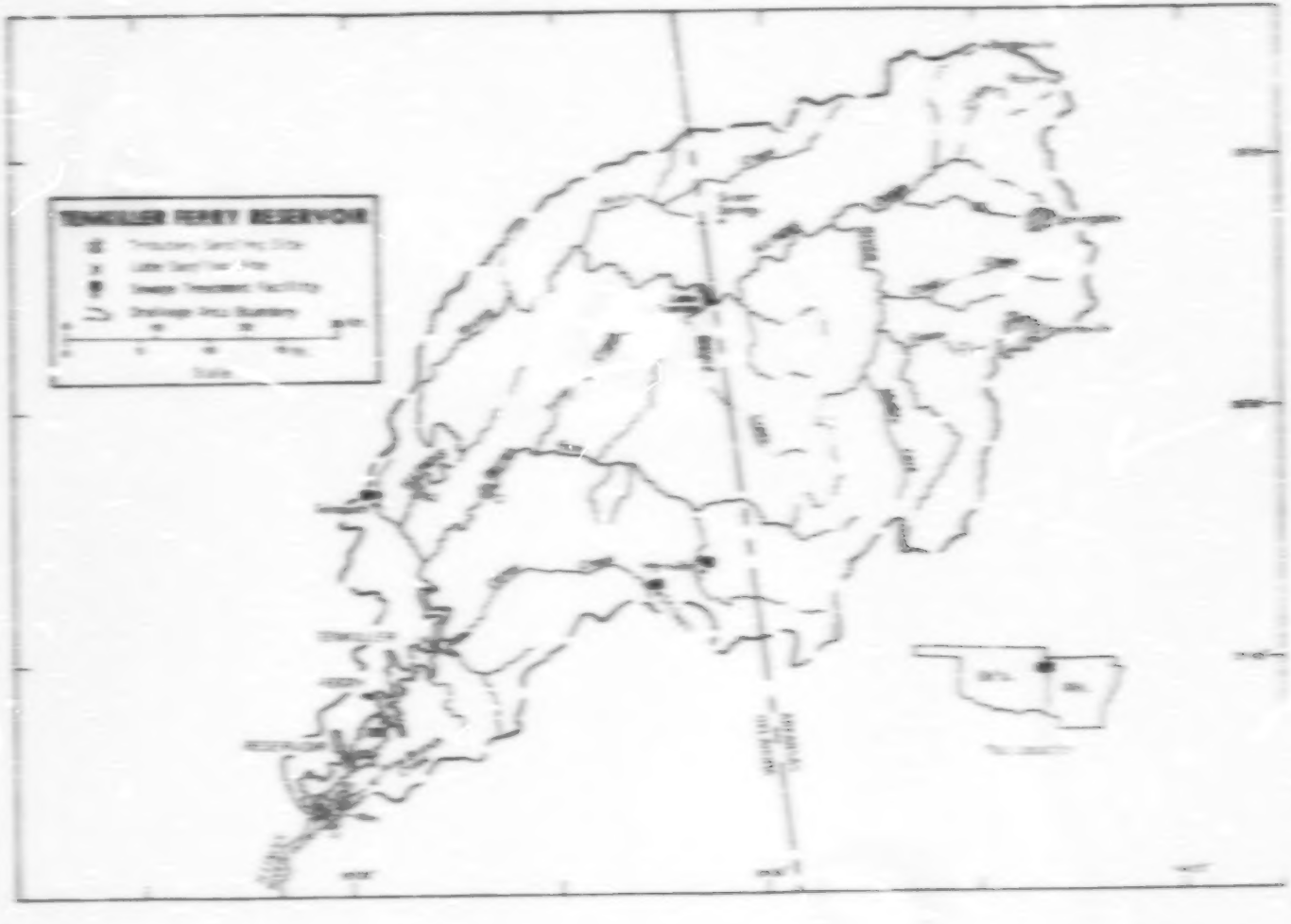
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis W. Milligan and Major James O. Haney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistence to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OKLAHOMA

LAKE NAME	COUNTY
Altus Reservoir	Greer, Kiowa
Arbuckle Lake	Murray
Lake Elsworth	Caddo, Comanche
Lake Eufaula	Haskell, McIntosh, Okmulgee, Pittsburg
Fort Cobb Reservoir	Caddo
Fort Supply Reservoir	Woodward
Foss Dam Reservoir	Custer
Lake Frances	Adair
Grand Lake O' The Cherokees	Mayes, Delaware, Craig, Ottowa
Lake Hefner	Oklahoma
Keystone Reservoir	Tulsa, Creek, Osage, Pawnee
Oologah Lake	Nowata, Rogers
Tenkiller Ferry Reservoir	Cherokee, Sequoyah
Lake Thunderbird	Cleveland
Wister Reservoir	LeFlore


TAMBLER FERRY RESERVOIR

REPORT ON TENKILLER FERRY RESERVOIR, OKLAHOMA
STORET NO. 4013

I. CONCLUSIONS

A. Trophic Condition:*

Based upon Survey data, Tenkiller Ferry Reservoir is considered eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Chlorophyll a values in the lake ranged from 0.1 µg/l to 24.6 µg/l with a mean of 6.6 µg/l. Potential for primary productivity as measured by algal assay control yield was high. Of the 16 Oklahoma lakes sampled in 1974 (including Lake Texoma), 10 had greater median total phosphorus, 4 had greater median inorganic nitrogen, and 7 had greater median orthophosphorus levels than Tenkiller Ferry Reservoir.

Survey limnologists did not report any problem conditions during their visits to the lake.

*See Appendix E.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Tenkiller Ferry Reservoir was limited by available phosphorus at the time the autumn assay sample was collected. The lake data suggest primary limitation by phosphorus at all other sampling times as well.

C. Nutrient Controllability:

1. Point sources -

Point sources were estimated to contribute 15.5% of the total phosphorus load during the sampling year. The towns of Tahlequah and Stilwell contributed 8.0% and 6.5%, respectively. Westville was estimated to contribute 1.0%.

The calculated annual phosphorus loading of 2.13 g P/m^2/yr is approximately twice that proposed by Vollenweider (1975) as "eutrophic" for a lake with such volume and retention time. Although elimination of all point source phosphorus loads would not reduce this annual loading to Vollenweider's "eutrophic" level (0.97 g P/m^2/yr), it would reduce the potential for the occurrence of nuisance conditions.

2. Nonpoint sources -

It is calculated that nonpoint sources contributed 84.5% of the total phosphorus input to Tenkiller Ferry Reservoir during the sampling year. Gaged tributaries contributed 71.1% of the total, and ungaged drainage areas were estimated to have contributed 12.6%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the Oklahoma Department of Pollution Control; maximum depth was provided by the Oklahoma Water Resources Board. Tributary flow data were provided by the Oklahoma District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 51.19 km^2.
2. Mean depth: 15.5 meters.
3. Maximum depth: 46.3 meters.
4. Volume: 793.445 x 10^6 m^3.
5. Mean hydraulic retention time: 240 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km²)	Mean Flow (m³/sec)
A-2 Illinois River	2,483.8	23.68
C-1 Barron Fork	796.1	8.45
Minor tributaries and immediate drainage -	839.8	9.04
Totals	4,118.7	41.17
2. Outlet - A-1 Illinois River	4,169.9	38.32

C. Precipitation:

1. Year of sampling: 137.3 cm.
2. Mean annual: 113.1 cm.

III. LAKE WATER QUALITY SUMMARY

Tenkiller Ferry Reservoir was sampled four times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 19.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 44.5 meters at Station 01, 36.9 meters at Station 02, 26.2 meters at Station 03, and 15.2 meters at Station 04. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

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B. Biological Characteristics:

1. Phytoplankton -

	Dominant Genera	Algae Units per ml
04/03/74	1. Stephanodiscus	1,605
	2. Melosira	401
	3. Chroomonas	289
	4. Cyclotella	96
	5. Cryptomonas	48
	Other genera	145
	Total	2,744
06/14/74	1. Cyclotella	369
	2. Melosira	276
	3. Cryptomonas	184
	4. Chlamydomonas	46
	Other genera	[illegible]
	Total	875
08/30/74	1. Achnanthes	873
	2. Raphidiopsis	467
	3. Synedra	416
	4. Stephanodiscus	374
	5. Nitzschia	333
	Other genera	666
	Total	3,119
10/21/74	1. Melosira	1,707
	2. Cyclotella	443
	3. Chroomonas	316
	4. Ankistrodesmus	253
	5. Tetraedron	190
	Other genera	695
	Total	3,604

F. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/03/74	01	2.9
	02	4.9
	03	7.1
	04	7.0
06/14/74	01	0.1
	02	0.2
	03	0.3
	04	0.7
08/30/74	01	6.6
	02	5.7
	03	6.6
	04	12.0
10/21/74	01	6.1
	02	7.1
	03	14.4
	04	24.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked - 10/21/74

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum Yield (mg/l dry wt.)
Control	0.020	0.320	5.2
0.05 P	0.070	0.320	10.0
0.05 P + 1.0 N	0.070	1.320	19.6
1.00 N	0.020	1.320	5.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity in Tenkiller Ferry Reservoir was high at the time of autumn sampling. There was a significant increase in yield over that of the control when orthophosphorus was added, indicating phosphorus limitation at that time. The addition of nitrogen alone did not result in an increase in yield over that of the control, and the simultaneous addition of the two nutrients produced the maximum increase in yield.

There is no spring assay available for Tenkiller Ferry Reservoir. However, mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake were 17/1 or greater on all sampling occasions, further suggesting primary limitation by phosphorus.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Oklahoma National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of April and May when two samples were generally collected. Sampling was begun in November 1974, and was completed in October 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oklahoma District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual concentrations in Pine Branch Creek at Station B-1 and mean annual ZZ flow.

The operators of the Tahlequah and Tahlequah wastewater treatment plants provided monthly effluent samples and corresponding flow data. Nutrient loads for the city of Westville wastewater treatment plant were estimated at 1.134 kg P and 3.401 kg N/capita/yr.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Stilwell	3,000	Trickling filter	0.831	Caney Creek/ Illinois River
Tahlequah	10,500	Activated sludge	3.679	Ross Branch/ Illinois River
Westville	1,000	Trickling filter	0.378**	Shell Branch/ Barren Fork

2. Known industrial -

Name	Product	Treatment	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Allen Canning Company	Canned vegetables	?	?	Tar Creek
Stilwell Cannery	Canned vegetables	Landfill disposal	?	Caney Creek/ Illinois River

*Treatment plant questionnaires; U.S.EPA, 1971.
**Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Illinois River	68,875	63.2
C-1 Barron Fork	8,605	7.9
b. Minor tributaries and immediate drainage (nonpoint load) -	13,685	12.6
c. Known municipal STP's -		
Stilwell	7,110	6.5
Tahlequah	6,725	6.0
Westville	1,135	1.0
d. Septic tanks* -	20	<0.1
e. Known industrial -		
Allen Canning Company	Unknown	---
Stilwell Cannery	Unknown	---
f. Direct precipitation** -	895	0.8
Totals	109,050	100.0
2. Output - A-1 Illinois River	59,305	
3. Net annual P accumulation -	49,745	

*Estimate based on 40 lakeside residences and 6 parks.
**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Illinois River	1,750,390	67.4
C-1 Barren Fork	434,890	16.8
b. Minor tributaries and immediate drainage (nonpoint load) -	321,290	12.4
c. Known municipal STP's -		
Stilwell	12,995	0.5
Tahlequah	18,015	0.7
Westville	3,400	0.1
d. Septic tanks* -	705	<0.1
e. Known industrial -		
Allen Canning Company	Unknown	---
Stilwell Cannery	Unknown	---
f. Direct precipitation** -	55,265	2.1
Totals	2,596,960	100.0
2. Output - A-1 Illinois River	2,070,280	
3. Net annual N accumulation -	526,670	

*Estimate based on 40 lakeside residences and 8 parks.
**Estimated (see NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Illinois River	28	705
Barron Fork	11	547

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
B-1 Pine Branch Creek	0.048	1.27

F. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not be applicable to water bodies with very short retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Tenkiller Ferry Reservoir	2.13
Vollenweider's "eutrophic" loading	0.92
Vollenweider's "oligotrophic" loading	0.46

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1971. "Inventory of Wastewater Treatment Facilities". EPA Publication No. OWP-1, Vol. 6. Office of Media Programs, Office of Water Programs, Washington, D.C.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

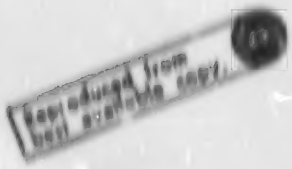
Square kilometers x 0.386 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile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APPENDIX B
TRIBUTARY FLOW DATA

[illegible] Flow Information for [illegible] 01/25/77

LAKE CASE [illegible] TEMPALLOW FLOWS ARE

TOTAL DRAINAGE AREA OF LAKE(SQ MI) = [illegible]

SUBDRAINAGE	AREA(SQ MI)	JAN	FEB	MAR	APR	MAY	NORMALIZED FLOWS(CMS) JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
[illegible]	[illegible]	35.47	45.21	41.79	61.73	81.73	41.09	47.57	29.46	28.67	18.41	28.48	29.49	36.32
[illegible]	[illegible]	38.69	38.59	34.65	43.84	54.03	23.59	15.43	11.69	7.58	11.52	17.78	17.74	23.68
[illegible]	[illegible]	8.48	11.69	17.41	24.02	27.13	15.01	7.82	2.52	1.47	2.04	3.34	5.13	8.45
[illegible]	[illegible]	8.48	11.41	15.49	15.57	22.37	6.24	4.23	3.45	2.44	3.68	5.48	7.17	8.04

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = [illegible]
SUM OF SUBDRAINAGE AREAS = [illegible]

TOTAL FLOW IN = [illegible]
TOTAL FLOW OUT = [illegible]

[illegible] FLOWS AND LAKE ELEVATIONS

SUBDRAIN	MONTH	YEAR	FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[illegible]	11	76	[illegible]	3	32,444				
	12	76	[illegible]	12	45,884				
	1	77	91,443	13	161,444				
	2	77	[illegible]	13	165,379				
	3	77	[illegible]	9	8,518				
	4	77	95,711	8	[illegible]	29	58,432		
	5	77	[illegible]	8	[illegible]	29	[illegible]		
	6	77	68,527						
	7	77	24,815	29	25,443				
	8	77	28,854						
	9	77	36,515						
	10	77	31,344	24	64				
[illegible]	11	76	[illegible]	2	158,424				
	12	76	24,357	12	31,432				
	1	77	36,244	14	22,443				
	2	77	44,574	16	24,334				
	3	77	84,614	6	44,271				
	4	77	35,833	13	24,438	28	45,432		
	5	77	31,788	4	[illegible]	29	65,345		
	6	77	17,339	22	36,748				
	7	77	8,426	24	12,459				
	8	77	12,341	17	24,824				
	9	77	42,756	6	5,345				
	10	77	45,317	24	15,449				

APPENDIX C

PHYSICAL AND CHEMICAL DATA

[illegible]

[illegible]
35 35 58.0 095 02 25.4 +
[illegible]
[illegible] OKLAHOMA
[illegible]

[illegible]

[illegible] 1-4ED362
4540 FEET [illegible] CLASS 08

DATE	TIME	ACCUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	OF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	10 [illegible]	11.6			139	7.40	98	0.048	0.388	0.480	0.438
	10	10 [illegible]	11.2			135	7.40	93	0.438	0.288	0.410	0.394
	10	10 [illegible]	11.8			136	7.40	94	0.439	0.288	0.420	0.394
	10	10 [illegible]	11.3			135	7.50	94	0.438	0.288	0.420	0.394
	10	10 [illegible]	6.9			133	7.38	94	0.458	0.298	0.440	0.378
	10	10 [illegible]	4.9			134	7.37	95	0.474	0.588	0.546	0.758
[illegible]	12	25 [illegible]	25.3		132	175	6.46	95	0.458	0.488	0.588	0.518
	12	25 [illegible]	24.3			168	6.47			0.388		
	12	25 [illegible]	23.4			167	7.46	98	0.458	0.388	0.548	0.488
	12	25 [illegible]	26.1			158	7.46	94	0.456	0.288	0.468	0.438
	12	25 [illegible]	28.4			123	7.48	98	0.456	0.388	0.468	0.398
	12	25 [illegible]	24.2			148	7.46	94	0.438	0.288	0.468	0.398
	12	25 [illegible]	25.2			146	7.48	94	0.438	0.288	0.468	0.398
	12	25 [illegible]	13.5			137	7.48	95	0.456	0.588	0.468	0.438
[illegible]	09	45 [illegible]	27.8		96	142	6.38	95	0.458	0.288	0.488	0.428
	09	45 [illegible]	27.2			152	6.36	94	0.444	0.448	0.388	0.428
	09	45 [illegible]	27.3			153	6.43	95	0.457	0.288	0.478	0.418
	09	45 [illegible]	28.6			152	7.46	94	0.446	0.288	0.496	0.418
	09	45 [illegible]	28.1			153	7.46	97	0.458	0.288	0.488	0.428
	09	45 [illegible]	25.3			147	7.39	93	0.458	0.288	0.448	0.414
	09	45 [illegible]	28.1			138	7.46	95	0.448	0.288	0.468	0.428
	09	45 [illegible]	24.4			135	7.51	96	0.398	0.488	0.288	0.398
	09	45 [illegible]	24.2			125	7.39	98	0.478	0.488	0.258	0.378
[illegible]	11	35 [illegible]	25.6		92	146	7.42	94	0.428	0.488	0.358	0.408
	11	35 [illegible]	25.6			145	7.42	94	0.428	0.258	0.358	0.408
	11	35 [illegible]	25.6			146	7.42	95	0.428	0.288	0.348	0.388
	11	35 [illegible]	25.6			146	7.42	94	0.428	0.288	0.348	0.388
	11	35 [illegible]	25.6			144	7.42	94	0.428	0.288	0.338	0.388
	11	35 [illegible]	25.6			143	7.47	95	0.428	0.388	0.356	0.408
	11	35 [illegible]	24.3			153	6.45	95	0.444	0.568	0.448	0.448
	11	35 [illegible]	24.4			146	6.47	96	0.428	0.288	0.228	0.408

* [illegible]
[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] RETRIEVAL DATE TODAY(YY-

[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]														
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]
[illegible]	11 30	[illegible]	[illegible]	[illegible]	
	11 30	[illegible]	[illegible]		
	11 30	[illegible]	[illegible]		
	11 30	[illegible]	[illegible]		
	11 30	[illegible]	[illegible]		
[illegible]	10 15	[illegible]	[illegible]	[illegible]	
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		[illegible]
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		
[illegible]	11 15	[illegible]	[illegible]	[illegible]	
	11 15	[illegible]	[illegible]		
	11 15	[illegible]	[illegible]		
	11 15	[illegible]	[illegible]		
	11 15	[illegible]	[illegible]		
[illegible]	10 15	[illegible]	[illegible]	[illegible]	
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		[illegible]
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		
	10 15	[illegible]	[illegible]		

[illegible]
35 41 25.4 [illegible] 57 48.4 W
[illegible]
[illegible]

[illegible]

[illegible]
[illegible] FEET [illegible] [illegible]

[illegible]

[illegible]

[illegible]

[illegible]														
[illegible]														
[illegible]														
[illegible]														

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			[illegible]	REMAINING
TO	DAY	FEET	[illegible]	[illegible]	PERCENT
[illegible]	12	[illegible]	[illegible]	7.8	
	12	[illegible]	[illegible]		
	12	[illegible]	[illegible]		
	12	[illegible]	[illegible]		
[illegible]	18	[illegible]	[illegible]	8.7	
	18	[illegible]	[illegible]		98.8
	18	[illegible]	[illegible]		
	18	[illegible]	[illegible]		
	18	[illegible]	[illegible]		
	18	[illegible]	[illegible]		
	18	[illegible]	[illegible]		
[illegible]	11	[illegible]	[illegible]	12.8	
	11	[illegible]	[illegible]		
	11	[illegible]	[illegible]		
	11	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	24.8	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]			1.1
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

DATE FROM	TIME OF	DEPTH FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	19	0.304	0.389	0.938	0.438	0.476
[illegible]	14	32	0.440	1.100	0.828	0.438	0.850
[illegible]	14	15	0.520	1.280	0.816	0.425	0.670
[illegible]			0.520	0.480	0.816	0.831	0.825
[illegible]	09	15	0.504	1.407	0.347	0.419	0.840
[illegible]	13	59	0.652	2.031	1.215	0.846	0.855
[illegible]	14	03	0.838	1.100	0.838	0.857	0.825
[illegible]	11	09	0.940	1.880	0.825	0.845	0.830
[illegible]	10	48	0.748	0.350	0.818	0.855	0.836
[illegible]	14	10	0.438	2.807	1.145	0.437	0.848

* VALUE [illegible] TO BE
USED THEN INCREASED

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	TOTAL	[illegible]	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L AS	MG/L AS
[illegible]	12	30		1.720	1.380	0.035	0.076	0.135
[illegible]	24	30		1.290	1.380	2.025	0.040	0.670
[illegible]	13	45		1.340	2.500	0.032	0.045	0.050
[illegible]	24	07		1.302	1.430	0.024	0.040	0.040
[illegible]	24	30		1.505	1.410	1.072	0.040	0.070
[illegible]	17	17		1.402	1.460	0.035	0.035	0.040
[illegible]	24	30		1.330	0.675	1.025	0.040	0.040
[illegible]	24	07		1.330	0.750	0.007	0.040	0.040
[illegible]	18	30		1.575	1.700	0.036	0.075	0.220
[illegible]	10	07		1.070	1.250	1.025	0.045	0.045
[illegible]	24	35		1.250	0.750	1.012	0.035	0.070
[illegible]	48	30		1.040	0.500	1.021	0.075	0.125
[illegible]	09	00		1.300	1.250	1.020	0.055	0.110
[illegible]	24	30		1.252	1.600	2.035	0.045	0.040

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF OKLAHOMA

[illegible]

[illegible] Code	Lake Name	[illegible] Total P	[illegible] Inlet P	[illegible] Area Sqkm	[illegible] Depth	[illegible] Area Sq Mi	[illegible] Inlet Outlet P
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

WEIGHT OF LAKES WITH MIXED VALUES TOWARDS OF LAKES WITH OTHER VALUES

LAKE CLASS	LAKE NAME	TOTAL P	DRAMA %	MEAN SEC	CALORIA	MEAN TO	ACCESS METRES P
4611	BLACK WATER LP	40 : 60	120 : 150	47 : 73	13 : 20	60 : 110	73 : 170
4612	WHITE LAKE	140 : 150	40 : 130	40 : 140	50 : 80	30 : 40	90 : 140
4613	LAKE ELIZABETH	60 : 120	90 : 130	60 : 120	30 : 40	60 : 90	97 : 170
4614	LAKE OPHELIA	20 : 30	50 : 50	27 : 40	160 : 250	47 : 70	30 : 40
4615	MIST COVE MEMBERS	80 : 110	70 : 110	67 : 130	7 : 10	60 : 110	67 : 170
4616	MIST HARBOR MEMBERS	30 : 50	67 : 100	0 : 60	27 : 40	160 : 250	60 : 90
4617	RISE ON MEMBERS	90 : 140	60 : 120	60 : 90	87 : 130	80 : 110	100 : 160
4618	LAKE PARKER	7 : 10	0 : 60	7 : 10	47 : 70	90 : 140	7 : 10
4619	WEST LAKE OF THE CREEK	10 : 20	7 : 10	40 : 60	60 : 90	20 : 30	10 : 70
4620	LAKE MEMBER	47 : 70	40 : 60	67 : 100	70 : 110	67 : 100	20 : 70
4621	MEMBERS MEMBERS	7 : 10	10 : 20	10 : 20	0 : 60	10 : 20	0 : 60
4622	SOLDIER LAKE	40 : 60	20 : 30	30 : 30	60 : 120	30 : 40	27 : 40
4623	TRIBUTE MEMBERS	67 : 100	27 : 40	100 : 150	67 : 100	3 : 50	50 : 70
4624	LAKE THUNDERCAR	87 : 130	60 : 90	50 : 80	40 : 60	50 : 80	40 : 170
4625	WATER MEMBERS	27 : 40	47 : 70	30 : 50	90 : 140	3 : 50	40 : 60
4626	TOWN LAKE	50 : 60	50 : 60	70 : 110	20 : 30	30 : 40	50 : 70